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## Preface

The Institute for Defense Analyses (IDA) prepared this document for the Office of the Director, Program Analysis and Evaluation under a task titled “Cost Research Symposium.” It contains an annotated version of a presentation the author delivered at the third annual Life Cycle Costing in Defence Conference, held on 17–18 June 2002 in London, England. The conference was sponsored by the LSC Group, TFD Services & Pennant Software Services, and was supported by the International Society of Logistics (known as SOLE). Attendees included representatives from the UK Defence Procurement Agency, the UK Ministry of Defence, the UK Defence Export Services Organisation, the Norwegian Defence Logistics Organisation, General Dynamics, BAE Systems, Eurocopter, Thales, Racal Instruments, and others.

This document was not reviewed within IDA for its technical content. The views and opinions it contains are attributable solely to the author.



# Cost in Cost Effectiveness

A presentation by

**Dr. Stephen J. Balut**

Institute for Defense Analyses

at the

**Life Cycle Costing in Defence Conference**

17-18 June 2002

I'm Steve Balut, Director of the Cost Analysis and Research Division at the Institute for Defense Analyses in Alexandria, Virginia. The Institute for Defense Analyses, or IDA, as we call it, is a non-profit corporation that provides advice to the Department of Defense on matters related to science and technology.

IDA assists the Department of Defense by conducting cost-effectiveness studies of alternative ways of performing defense missions. The subjects of several recent studies include the F-22 tactical aircraft, the Joint Strike Fighter, the C-17 cargo aircraft, and airborne electronic attack systems. Cost-effectiveness analysis is central to our business. When conducting cost-effectiveness analyses, the Cost Analysis and Research Division of IDA forecasts the life cycle costs of current and prospective weapon systems.

# Introduction

- ***Cost-Effectiveness Analysis***: an analytical technique routinely applied to aide in selecting the best way to perform defense missions under constrained budgets
- ***Role of Cost in Cost-Effectiveness Analysis***: creates incentives for contractors and military departments that can bring unexpected, undesirable results
- ***Policing Costs***: counters adverse incentives and strengthens integrity of the process

Everyone here is familiar with the fundamental idea of cost-effectiveness analysis. This technique provides visibility into both the operational and economic implications of alternative ways of performing a defense mission. It is important to note that such analyses say nothing about the social, distributional, or political aspects of the choice at hand. These are considerations that decision makers must fold into their thinking. But knowing what each alternative can do and what it costs forms a sound basis for proceeding with a choice among competing alternatives.

The cost part of cost-effectiveness provides visibility and understanding of the costs that will be borne if an alternative is selected. All other things being equal, the lower the cost of an alternative, the more efficient it appears and the more likely it is to be selected and funded. The rub here is that, in many cases, proponents of an alternative—that is, contractors and military departments—help prepare the cost estimates. This process can create incentives that lead to undesirable results.

Decision systems that fail to deal directly with this natural but destructive incentive are doomed to failure. The effects are loss of capability and disruptive programming and budgeting. This problem can and has been countered by policing cost estimates. I will have a lot to say about how to maintain the integrity of the decision process by policing cost estimates at the appropriate place and time.



# Cost-Effectiveness Methodology

- Identify mission and alternative ways of accomplishing it
- Estimate effectiveness of alternatives
- *Estimate costs of alternatives*
- *Combine costs and effectiveness to reveal preferred alternatives*
- List assumptions and limitations of analysis

Just to make sure we're all talking about the same thing, I will run down the steps involved in conducting a cost-effectiveness study.

The problem starts with identification of a defense mission, such as moving war fighters and their equipment from their bases in one part of the world to a point of battle in another. Alternatives are identified for accomplishing the objective. In this example, alternatives could include different mixes of aircraft, ships, and land vehicle systems.

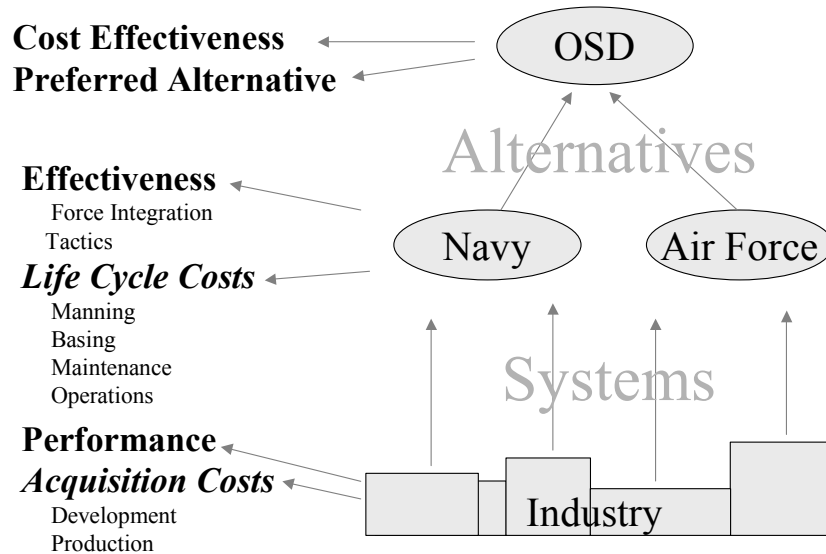
The effectiveness of each alternative is then estimated. This is accomplished by calculating measures of effectiveness that are representative of the task. Simulation is a common way to do this step. In the example of moving forces to a point of battle, a measure that has been used is ton-miles delivered over some fixed period of time.

The next step is to develop costs of each alternative. This involves full life cycle costs of systems involved along with other relevant costs.

These costs are then combined with measures of effectiveness in a way that reveals the preferred alternatives. In the example, the preferred alternative might be the one that delivers a given amount of ton-miles per day over some period of time for the least cost.

Finally, the analyst owes the decision maker an explanation of the assumptions, data sources, uncertainties, and limitations of the analysis.

# Estimating Costs



This slide depicts the sources and flows of data and other information that support a cost-effectiveness analysis. Industry is one of the basic sources of information on systems. This information includes descriptions of physical and technical features of the systems, the performance of the systems, and forecasts of the costs of developing and producing the systems. Industry works closely with the prospective buying military departments, providing cost estimates for proposed contract activities.

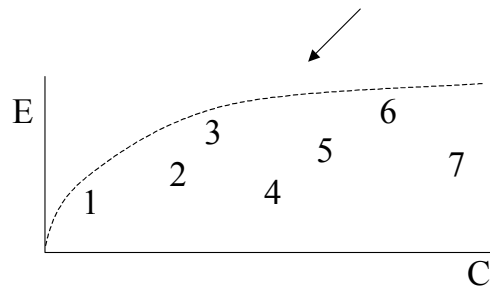
The military departments work with industry to add operating and support cost estimates based on the concept of operations, manning, basing, maintenance policy, and other factors. This extends the industry acquisition cost estimate to a military department life cycle cost estimate. The military departments also estimate the effectiveness of forces that include the systems of interest.

The Office of the Secretary of Defense (OSD) receives these inputs from industry and the military departments, combines the cost and effectiveness estimates, and identifies the preferred alternatives.

United States statute requires an independent cost estimate be performed as a weapon system approaches a milestone decision, such as entrance into development or production. That is, an estimate must be prepared by an organization that is separate from the buying military department. These estimates are now done by the OSD Cost Analysis Improvement Group, a part of the OSD Staff. However, prior to about a decade ago, the so-called “independent estimates” were performed by the buying military departments.

## Role of Cost

- Fix effectiveness level: least cost alternative is preferred
- Cap costs: alternative with greatest effectiveness is preferred
- Allow both cost and effectiveness to float: indifference among alternatives along “Efficient Frontier”



*Lower cost increases chance of being preferred alternative*

The role of cost in cost-effectiveness analyses varies depending upon the approach applied. If effectiveness is fixed at some level, then the least cost alternative wins. Another approach is to cap costs and calculate which alternative achieves the highest level of effectiveness under this budget constraint. A third way to conduct the analysis is to allow both costs and effectiveness to float, calculate both for all alternatives, then array these data as shown in the graph on the slide.

The graph shows which alternatives are dominated by other alternatives. For example, alternative 4 is dominated by both alternatives 2 and 3 because the effectiveness levels of both 2 and 3 are higher than 4, and 4 costs more than either 2 or 3. It also reveals those alternatives that are not dominated—in this example, alternatives 1, 3, and 6. These non-dominated alternatives array themselves in an “efficient frontier” pattern. That is, they tend to create a frontier along which the decision maker should be indifferent to which is selected from a cost-effectiveness perspective. At this point, the decision maker can make his choice based on affordability, minimum desired effectiveness level, or other factors. In practice, once the frontier is identified, additional alternatives can be constructed near the frontier at points of particular interest.

The bottom line is that no matter the approach, alternatives with lower cost are more likely to be the preferred alternative.

## Incentives to “Buy-In”

- Programs once started rarely get cancelled
  - Incentive to get “foot in the door”
  - Deal with reality later
- Win can establish monopoly position
- Early “learning” enhances competitive advantage for future contracts
- Future contract modifications offer opportunities to recover from buy-in

Following this process, both industry and the buying military department have strong incentives to provide cost estimates that are optimistic. Our experience shows these early optimistic estimates are rarely, if ever, achieved. Skeptics of this process say proponents lowball early estimates to get their foot in the door, or nose under the tent, intending to deal with expected cost growth later, after the Department of Defense is committed to the system.

Winning a competition puts the contractor in an advantageous position. It could establish a monopoly position for the contractor, enhancing his negotiating position for later lots in the acquisition. In addition, we all know that the early units are the most expensive due to the “cost progress” or “learning” phenomenon. Once down the steep part of the learning curve, the winning contractor has a distinct advantage over other contractors who must start back up the learning curve at high cost unit one.

The real ace in the hole for the winning contractor is full knowledge that the system will evolve with time as technology advances. The government will come back to the contractor requesting modifications to the original contract to add capabilities facilitated by such advances. Once the contract is reopened, cost estimates are revised, providing repeated opportunities to recover from early lowball estimates.

## Damage of Cost Overruns

- Budgets squeezed
  - Program stretch-outs, delays, cancellations
  - Financial plans disrupted
- Result in reduction in capability
  - Fewer systems
  - Systems arrive later than needed
  - Other capability may be delayed or cancelled to pay for overrun

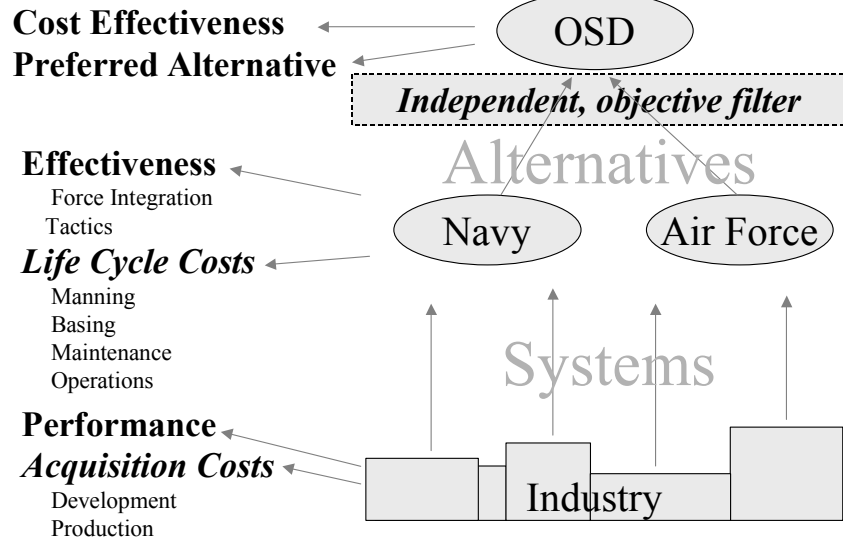
*Warfighters must adapt to reduced capabilities*

Given the factors just discussed, cost growth on major weapon system acquisitions seems inevitable. In spite of repeated episodes of massive cost growth, our budgeting process continues to join in the early optimism of the buying military departments who prepare low budget estimates. You've heard the phrase "keep their feet to the fire." In practice, that means budget to the low estimate and see if they can pull it off. They usually cannot.

Cost growth causes serious budget problems. Program stretch-outs and delays result in fewer weapon systems entering the force. Cancellations are rare, but they do occur. Examples include the A-12 and the Crusader. Systems that do enter the force do so later than planned, sometimes with reduced capabilities. Further, paying for cost overruns takes dollars away from other planned acquisitions. That means even fewer weapons and later capabilities, even in areas not experiencing cost growth.

In the end, cost growth translates to a reduced warfighting capability.

# Policing Costs



What can be done to police cost estimates flowing from industry and the military departments? I showed this diagram previously, but I've inserted a new box between the military departments and OSD. This box represents a point in the process where cost estimates and related information can be reviewed for realism and completeness. Let's compare this placement to where the filter has been located in the past.

In the early 1970s, the military departments performed this filter function in the U.S. Department of Defense. In terms of the diagram, this would have the new box down at the location of the military departments. Placing the filter function there does nothing to solve or counter the perverse incentives problem. Since the early 1990s, the filter function has been performed within the Office of the Secretary of Defense, many times with the assistance of organizations like IDA. This placement, shown in the diagram, can work depending upon the nature of the filter.

# Filter

- Independent, objective
- No conflict of interest—arm’s length relationship with advocates
- Highly capable
  - Latest and “best” methods
  - Access to industry and government cost experiences
  - Knowledge of trends in technology and cost
- Experience
  - Participation in programming, budgeting, and acquisition processes
  - Awareness of common pitfalls

The group that performs the policing function must be independent and objective. That is, it must (1) have no vested interest in the outcome of the pending decision and (2) be free of any possible bias towards any of the alternatives. Further, the group should be free from conflicts of interest, particularly with industry, and maintain an arm’s length relationship with advocates in the military departments.

These conditions are necessary, but not sufficient. The filtering organization must also be highly capable—preferably the best in the business of defense cost estimating—and use the latest and best methods. While maintaining independence and objectivity, the group must have ready access to both industry and government cost experiences and be knowledgeable of trends in both technology and costs.

Further, the group must be experienced in programming and budgeting and have a full understanding of the acquisition process. They need to know where to look in complex budgets to identify the funding streams. Prior experience with funding sleights of hand is also helpful.

## Realistic, Comparable Costs

- Realistic
  - Consistent with historical costs for similar systems and operations
  - Alignment with trends in both technology and cost
- Comparable
  - Estimate probability distribution of life cycle cost for each alternative
  - Use estimates of life cycle cost at same risk level for all alternatives

Policing cost estimates means ensuring that they are realistic, complete, and comparable across all alternatives. One test for realism is to look for consistency with cost experiences on analogous systems and operations while taking differences into account. This test can be strengthened by placing estimates along trend lines that display measures of technological progress along with the costs of achieving this progress. An example of this technique would be to plot the increasing trend in cost associated with increasing thrust-to-weight ratios achieved by aircraft engines. This trend line could be used to forecast the increase in cost that might be expected from yet another proposed advance in engine thrust-to-weight.

Policing includes ensuring that costs of alternatives are comparable. They must include and exclude things in a consistent way. Uncertainties should be dealt with directly by estimating probability distributions of costs and presenting estimates at the same risk levels.



## Effects of Policing Costs

- More credible cost estimates
- Fewer and smaller cost overruns
- Less disruptive budget process
- Greater confidence in system

*Less loss of warfighting capabilities*

Effective policing of costs at the right point in the process pays big dividends. It will not remove incentives to lowball estimates. Industry and advocates in the military departments will continue to suffer from this affliction. But, policing will make lowball cost estimates less likely. Advocates will know someone is watching. Proposals with unrealistic cost estimates will not pass muster. More credible cost estimates will be demanded before allowing acquisition programs to pass through major milestones.

The initial impact of policing will likely be higher initial estimates for systems and operations, but the downstream effect should be fewer and smaller cost overruns, less frequent program stretches, smaller reductions in program quantities, and fewer program cancellations due to unexpected hemorrhaging of costs. This, in turn, results in less disruption in budgeting, greater confidence in the system, and better planning overall.

The greatest benefit to a strengthened process is getting sufficient warfighting capability where it is needed when it is needed, rather than not enough and too late.

## Summary

- Cost-effectiveness intended to maximize warfighting capabilities under constrained defense budgets
- Cost-effectiveness methodology prefers least cost alternatives
- Incentives to “buy-in” can lead to unintended effects: reductions in warfighting capabilities
- Adverse incentives can be countered: police process by implementing independent, objective filter to ensure costs are realistic and consistently applied across all alternatives

In summary, cost-effectiveness analysis has been applied to aid in the selection of efficient ways to perform defense missions under constrained budgets. The logic of the analysis technique is sound. However, the role of cost in the decision process creates incentives that can lead to undesirable results. Past failures of the process can be traced to defective, optimistic costing of systems and alternatives. The incentive to buy in is strong. Near-term rewards for winning are substantial. However, the long-term effects degrade warfighting capabilities and disrupt defense management.

We can do better. Adverse incentives created by the role of cost in cost-effectiveness analysis cannot be avoided, but they can be countered. We can police the costs flowing through the system acquisition process by inserting an independent, objective filter. This will result in a more orderly, efficient, and credible system. The damaging effects of cost overruns can be reduced, leading to improved warfighting capabilities.

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